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X-BAND POWER FET DEVELOPMENT

H. C. Huang and J. J. Napoleon
RCA Laboratories
Princeton, New Jersey 08540

DECEMBER 1976

FINAL REPORT
For Period from 1 December 1975 to 31 December 1976

Prepared for U. S. Army Missile Command
Redstone Arsenal, Alabama 35809

UNCLASSIFIED

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Power combining on the chip
Intercell connection

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Techniques for cellular combining at X-band frequencies to increase the output power have been developed. Multicell FETs have been fabricated and evaluated. Several multicell FETs with an output power of 800 to 900 mW, a small signal gain of 5 to 6 dB, and a power-added efficiency of 7 to 20% at the 9- to 10-GHz band have been delivered to the contracting agency. The performance of these devices meets the goals of this program.

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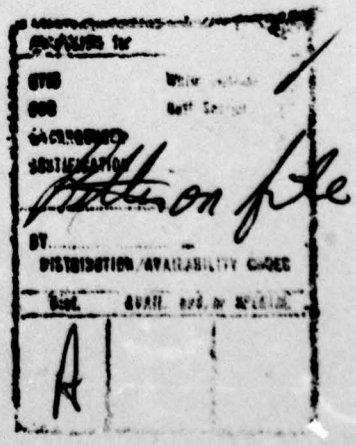
PREFACE

This Final Report describes research performed under contract No. DAAH01-76-C-0357 at RCA Laboratories in the Microwave Technology Center, F. Sterzer, Director. It describes work done from 1 December 1975 to 31 December 1976. The Project Supervisor is S. Y. Narayan; the Principal Investigators are H. C. Huang and J. J. Napoleon. The technical support personnel include W. F. Reichert, R. J. Matarese, P. F. Pelka, and A. San Paolo.



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SECTION I

INTRODUCTION

The purpose of this program is to develop techniques for combining more than one cell of FET at the chip level to increase the output power of GaAs field effect transistors at X-band frequencies. The goals are to achieve device performance of 750 mW at 2-dB gain compression, with a linear gain of 5 dB and a power-added efficiency of 10% in the 9- to 10-GHz frequency band. During the course of this program, we have processed a number of GaAs wafers with five cells on a pellet. We have also developed a technique of combining these cells by gold ribbons. Devices having three, four, or five cells combined were fabricated and tested. Four of these devices with an output power of 800 to 900 mW, a small signal gain of 5 to 6 dB, and a power-added efficiency of 7 to 20% at the 9- to 10-GHz band have been delivered to the contracting agency. The performance of these devices meets the program goals.

During the final period of this program, RCA Laboratories, under the sponsorship of Air Force Avionics Laboratory, undertook the development of a new device pattern. This new FET pattern, designated as 16G, has 16 gates in one cell. The total gate width is 2400 μm per cell. The 16G device is equivalent to the combined 4-cell devices delivered in this program. The design goal of the 16G FET is 1-W output power at X-band. Although the 16G FETs are still under development, the first few wafers processed showed promising results. Three of the experimental 16G FETs were also delivered to the contracting agency for evaluation. These experimental devices showed a small signal gain of 6 to 6.9 dB, with an output power of 500 to 600 mW at 8 GHz.

SECTION II

4-GATE, MULTICELL GET

The 4-gate FET has four gate stripes per cell. The unit gate stripe width is 150 μm. The total gate width is 600 μm per cell. Figure 1 is a scanning electron micrograph of the 4-gate pattern. There are five cells on a pellet. These cells can be paralleled to increase the output power. During the course of this program, various techniques for intercell connection were investigated. To parallel the cells at the chip level, the gate pads and also the drain pads of the cells are connected together by gold wires or ribbons. Several techniques, such as pulsed thermal-compression bond, cw thermal-compression bond, ultrasonic bond, welding and soldering were investigated. We concluded that either the pulsed thermal-compression bond (Hughes model HPB-360 pulse bonding system) or ultrasonic bond (Kulicke and Soffa model 422 ultrasonic bonding system or equivalent) would be preferable. Furthermore, we prefer gold ribbons to gold wires for intercell connection to minimize the parasitic inductance. In X-band frequencies, the parasitic inductance will degrade both the bandwidth and the gain of the amplifier.

Table 1 summarizes the four FETs delivered to the contracting agency. Detailed P_{out}-P_{in} characteristics at 9, 9.5, and 10 GHz and S-parameter data are included in Appendix 1.

TABLE 1. PERFORMANCE OF MULTICELL FETs AT 10 GHz

Device No.	Small Signal Gain (dB)	cw Output Power (mW)	Power Gain (dB)	Power-added Efficiency (%)	No. of Cells
B336b-4	5.2	844.6	3.5	19.7	3-cell
B336b-7	4.9	798	3.2	10.6	4-cell
B336b-45	4.7	784.7	3.1	7.0	5-cell
B336b-82	5.7	837.9	4.4	12.9	4-cell

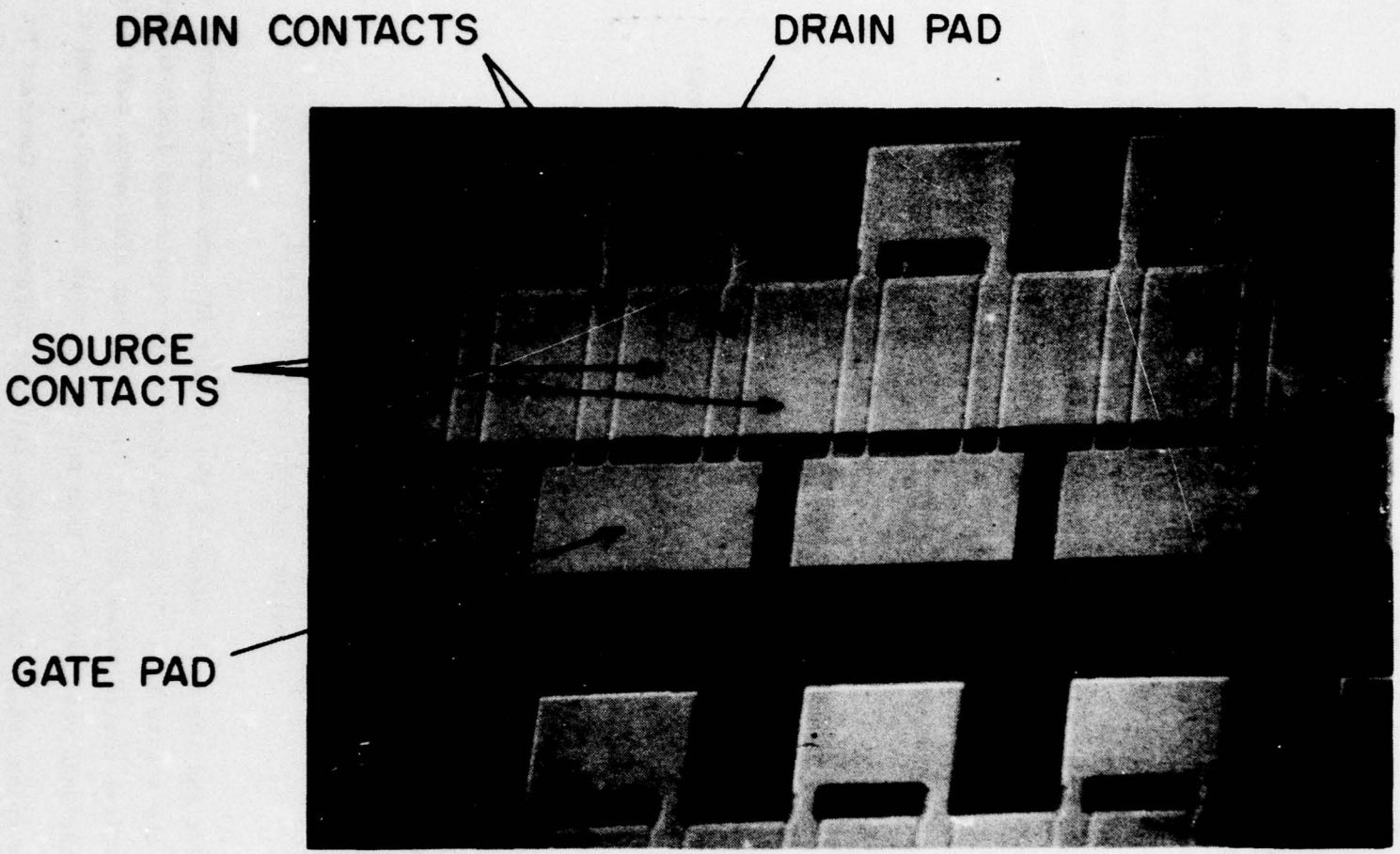


Figure 1. Photograph of power MESFET.

SECTION III

16-GATE FET

Toward the end of this program RCA Laboratories started the development of a new FET pattern.* This new pattern is designated as 16G and is shown in Fig. 2. There are 16 gates paralleled in one cell. The unit gate width is 150 μm, as in the 4-gate structure. The total gate width is 2400 μm, equivalent to four cells in parallel. The 16-gate FET is designed to provide 1-W output power at X-band. Since all the gates and drains are parallel in the batch device fabrication process, no individual intercell paralleling is needed.

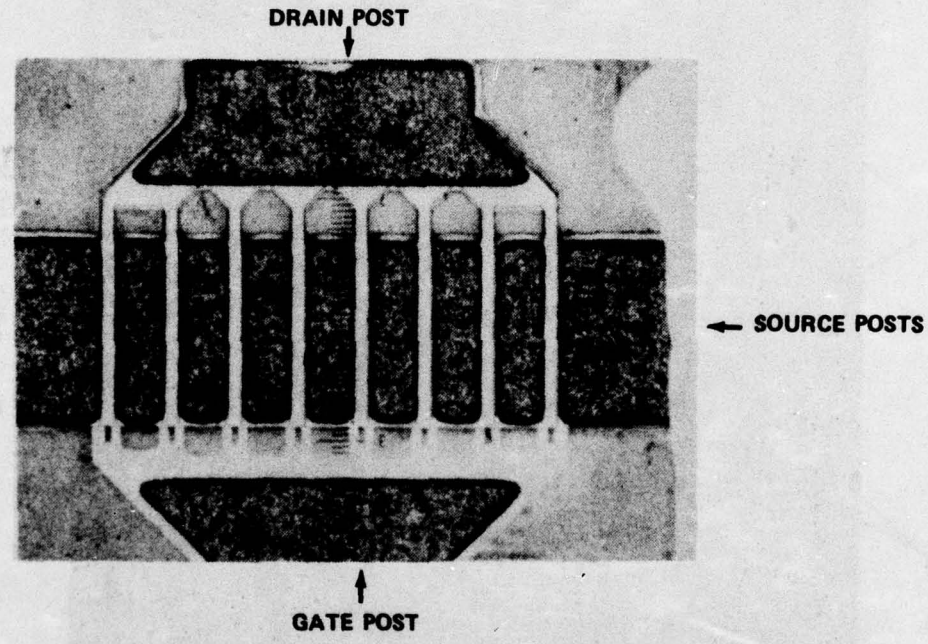


Figure 2. 16-Gate FET designed for 1-W output in X-band. Gold posts are plated in the source, gate and drain areas. The pellet size is 25 x 30 $(mil)^2$.

The source and the drain areas of the 16-gate FET are about one-half of the areas of the 4-gate FET. This reduction in the source and drain length not only minimizes the rf phase shift in the cell, but also makes more effective use of the GaAs real estate. This new design will eventually lead to high

*This work is sponsored by the Air Force Avionics Laboratory, Contract No. F33615-76-C1144.

performance and low cost. The pellet size of the 16-gate FET is 0.025 x 0.030 $(in.)^2$. This is a better form factor than that of the 4-gate FET with a size of 0.020 x 0.047 $(in.)^2$.

At the time this final report was prepared, the 16-gate FET was still under development. However, several GaAs wafers were processed, and the initial results are encouraging. Three experimental 16-gate FETs with associated P_{out}-P_{in} data at 8 GHz were delivered to the contracting agency for evaluation. The performance of these 16-gate FETs is summarized in Table 2. Detailed P_{out}-P_{in} data are included in Appendix 2.

TABLE 2. PERFORMANCE OF 16-GATE FET AT 8 GHz

Device No.	Small Signal (ss) Gain (dB)	cw Output Power (mW)	Power Gain (dB)	Power-added Efficiency (%)	Remark
2973-24	6.9	273.7	5.7	13.6	When tuned for best gain, an ss gain of 8.6 dB was observed.
2973-34	[illegible]	511	4.4	10.5	
2975-75	6.0	618.8	4.5	16.3	

SECTION IV

CONCLUSION

Techniques for combining multicell GaAs FETs to increase the output power at X-band have been developed. Several multicell FETs with an output power of 800 to 900 mW, a small signal gain of 5 to 6 dB, and a power-added efficiency of 7 to 20% were delivered to contracting agency. The performance of these devices meets the goals of this program. In addition, three experimental 16-gate FETs were also delivered for evaluation purposes.

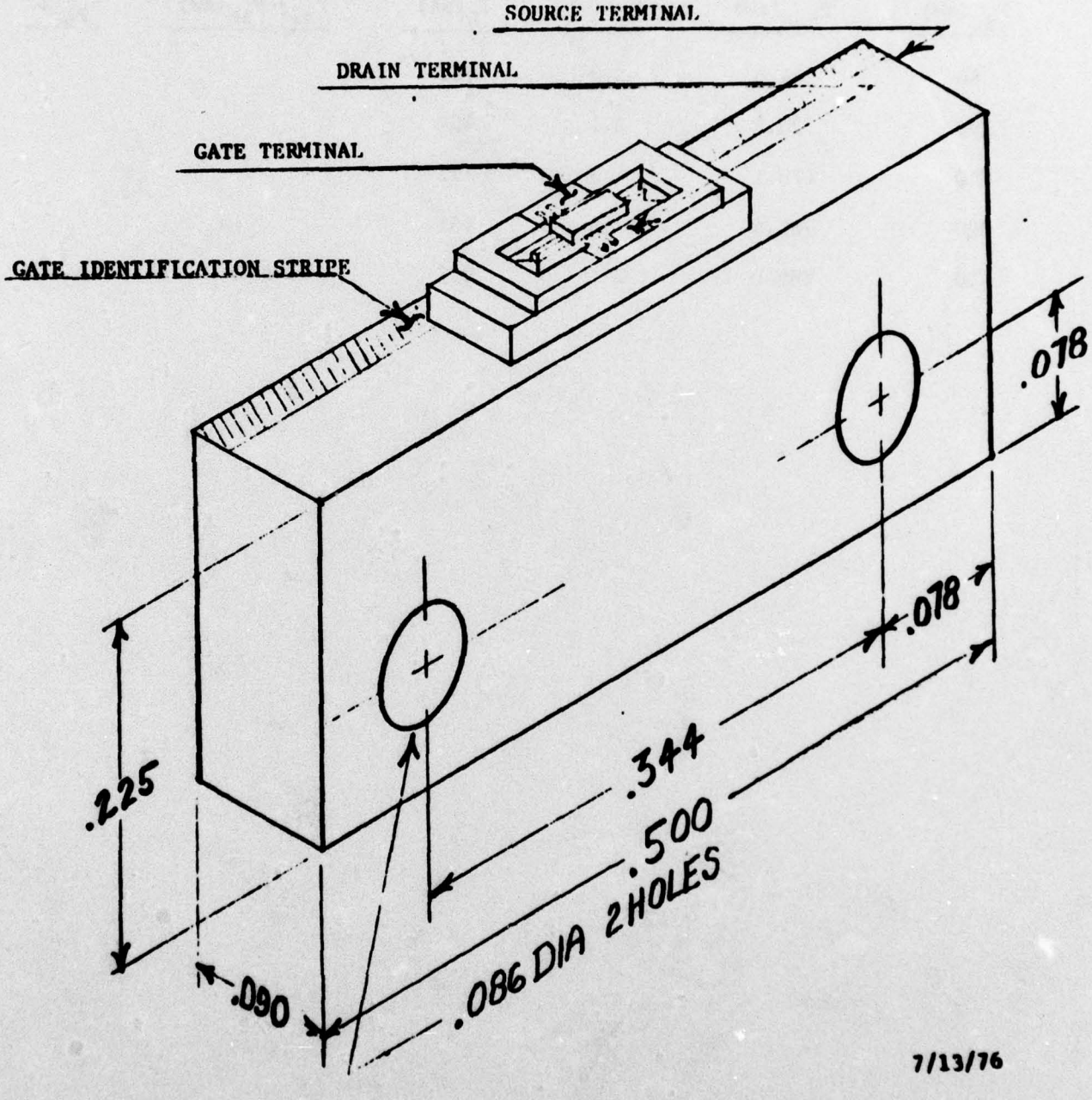
APPENDICES

APPENDIX A

DATA PACKAGE FOR MULTICELL FETs

RCA Corporation
David Sarnoff Research Center
Princeton, New Jersey

FIELD EFFECT TRANSISTOR



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RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: B336b-4

V_D = 7.5 V, I_{DSSO} = 600 mA, V_G = -2 V, f = 9.0 GHz

P_{in}(mW)	P_{out}(mW)	G (dB)	I_D(mA)	P_{out}-P_{in}(mW)	η_{PA}(%)
80	254.0	5.0	385		
160	520.7	5.1	404		
240	673.1	4.5	393		
320	787.4	3.9	351		
400	889.0	3.5	317	489.0	20.6

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: B336b-4

V_D = 7.5 V, I_{DSSO} = 600 mA, V_G = -2 V, f = 9.5 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	$P_{out}-P_{in}$(mW)	η_{PA}(%)
76	266.70	5.5	381		
152	546.1	5.6	399		
228	679.5	4.7	376		
304	774.7	4.1	338		
380	850.9	3.5	308	470.9	20.4

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: B336b-4

V_D = 7.5 V, I_{DSSO} = 600 mA, V_G = -2 V, f = 10 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	P_{out}-P_{in}(mW)	η_{PA}(%)
76	231.4	4.8	374		
152	505.4	5.2	401		
228	651.7	4.6	385		
304	758.1	4.0	345		
380	844.55	3.5	315	464.55	19.66

NEW MEAS? Y

CONN DEVICE B336B-4 V_{DS}, V_{GS}, I_{DS} 2.5,-1,400 3CELLS 8/18/76 JJN

S --MAGN AND ANGLES:

FREQ	11		21		12		22	
8000.0	.928	142	.656	-24	.056	-53	.604	172
8500.0	.940	144	.550	-34	.047	-61	.723	167
9000.0	.915	148	.446	-40	.041	-64	.756	166
9500.0	.906	153	.419	-41	.041	-63	.799	168
10000.0	.834	156	.398	-45	.040	-64	.740	168
10500.0	.815	150	.461	-48	.046	-65	.693	157
11000.0	.824	131	.515	-63	.052	-75	.739	138
11500.0	.859	110	.467	-89	.048	-98	.792	114
12000.0	.889	100	.351	-108	.036	-121	.803	98

TASK? PARAM? LIST? 2

NEW MEAS? N

FREQ	H21	S21	G1	G2	GMAX	U	K
8000.0	4.6	-3.7	8.6	2.0	6.9	.23	.80
8500.0	5.2	-5.2	9.3	3.2	7.3	.32	.65
9000.0	3.7	-7.0	7.9	3.7	4.6	.18	1.57
9500.0	4.7	-7.6	7.5	4.4	4.3	.19	1.63
10000.0	3.1	-8.0	5.2	3.4	.6	.07	4.26
10500.0	1.6	-6.7	4.7	2.8	.9	.07	3.85
11000.0	-.3	-5.8	4.9	3.4	2.6	.11	2.32
11500.0	-4.1	-6.6	5.8	4.3	3.5	.16	1.78
12000.0	-7.8	-9.1	6.8	4.5	2.2	.12	2.74

TASK? PARAM? LIST? 1,4

NEW MEAS? N

Z --MAGN AND ANGLES:

FREQ	11		21		12		22	
8000.0	13.277	79	22.136	-8	1.879	-36	13.010	10
8500.0	15.842	82	17.393	-13	1.506	-40	9.535	29
9000.0	13.852	79	13.855	-19	1.268	-43	9.030	38
9500.0	11.611	76	12.606	-24	1.223	-46	7.342	39
10000.0	10.976	64	12.807	-29	1.272	-49	8.984	32
10500.0	13.695	66	15.817	-26	1.581	-43	13.227	44
11000.0	22.723	74	18.991	-25	1.919	-36	19.602	64
11500.0	34.082	80	20.106	-29	2.079	-39	32.134	75
12000.0	41.156	83	17.466	-36	1.773	-49	42.691	77

TASK? PARAM? LIST?

TASK? PARAM? LIST? 1,1

NEW MEAS? Y

CONN DEVICE B336B-4 V_{DS}, V_{GS}, I_{DS} 7.5,-2,350 3CELLS 8/18/76 JJN

S --MAGN AND ANGLES:

FREQ	11		21		12		22	
8000.0	.919	154	.725	-21	.065	-56	.606	175
8500.0	.935	148	.599	-30	.056	-63	.698	170
9000.0	.917	152	.490	-35	.048	-66	.743	168
9500.0	.900	157	.459	-37	.047	-64	.776	171
10000.0	.831	160	.442	-40	.046	-65	.712	172
10500.0	.808	155	.510	-42	.055	-65	.656	163
11000.0	.807	136	.583	-58	.062	-76	.691	145
11500.0	.848	115	.545	-83	.060	-99	.747	120
12000.0	.879	104	.418	-104	.046	-121	.770	102

TASK? PARAM? LIST? 2

NEW MEAS? N

FREQ	H21	S21	G1	G2	GMAX	U	K
8000.0	5.6	-2.8	8.1	2.0	7.3	.27	.69
8500.0	5.8	-4.5	9.0	2.9	7.4	.33	.61
9000.0	4.9	-6.2	8.0	3.5	5.3	.23	1.23
9500.0	5.6	-6.8	7.2	4.0	4.5	.20	1.54
10000.0	4.1	-7.1	5.1	3.1	1.1	.08	3.66
10500.0	3.1	-5.9	4.6	2.4	1.2	.08	3.34
11000.0	1.8	-4.7	4.6	2.8	2.7	.11	2.22
11500.0	-2.0	-5.3	5.5	3.5	3.8	.17	1.59
12000.0	-5.9	-7.6	6.4	3.9	2.8	.14	2.18

TASK? PARAM? LIST? 1,4

NEW MEAS? N

Z --MAGN AND ANGLES:

FREQ	11		21		12		22	
8000.0	10.967	75	24.321	-8	2.173	-43	12.780	3
8500.0	13.787	81	19.036	-12	1.771	-44	9.805	20
9000.0	12.136	78	15.204	-18	1.492	-48	8.681	30
9500.0	9.940	73	13.958	-23	1.421	-50	7.281	28
10000.0	9.445	59	14.358	-28	1.494	-53	8.906	18
10500.0	11.731	61	17.561	-26	1.892	-48	12.281	29
11000.0	19.989	71	21.383	-26	2.295	-43	17.343	54
11500.0	30.798	79	22.716	-29	2.496	-45	28.769	70
12000.0	38.301	82	20.072	-36	2.216	-54	39.757	75

TASK? PARAM? LIST?

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: B336b-7

V_D = 7.5 V, I_{DSSO} = 900 mA, V_G = -2 V, f = 9.0 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	P_{out}-P_{in}(mW)	η_{PA}(%)
80	217.8	4.3	600		
160	471.9	4.7	637		
240	659.5	4.4	609		
320	786.5	3.9	571		
400	889.4	3.5	542	489.4	12.0

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: B336b-7

V_D = 7.5 V, I_{DSSO} = 900 mA, V_G = -2 V, f = 9.5 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	P_{out}-P_{in}(mW)	η_{PA}(%)
76	215.90	4.5	596		
152	469.9	4.9	635		
228	622.3	4.4	602		
304	704.8	3.7	565		
380	793.8	3.2	537	413.8	10.3

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: B336b-7

V_D = 7.5 V, I_{DSSO} = 900 mA, V_G = -2 V, f = 10 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	$P_{out}-P_{in}$(mW)	η_{PA}(%)
76	226.1	4.7	596		
152	465.5	4.9	634		
228	611.8	4.3	599		
304	711.55	3.7	558		
380	798	3.2	526	418.0	10.6

NEW MEAS? Y

CONN DEVICE R336B-7 V_{DS}, V_{GS}, I_{DS} 4.5,-5.420 4 CELLS 8/18/76 JJN

S --MAGN AND ANGLES:

FREQ	11		21		12		22	
8000.0	.967	134	.599	-39	.070	-88	.708	124
8500.0	.986	103	.517	-72	.062	-120	.762	97
9000.0	.956	82	.413	-101	.053	-147	.752	70
9500.0	.946	68	.377	-123	.051	-166	.746	52
10000.0	.963	44	.380	-153	.054	164	.724	25
10500.0	.899	17	.411	-178	.060	139	.677	-8
11000.0	.843	-22	.452	144	.065	106	.754	-45
11500.0	.877	-67	.440	101	.064	63	.793	-85
12000.0	.929	-105	.353	57	.054	19	.751	-121

TASK? PARAM? LIST? 2

NEW MEAS? N

FREQ	H21	S21	G1	G2	GMAX	U	K
8000.0	-1.8	-4.5	11.9	3.0	10.5	.89	-.21
8500.0	-4.9	-5.7	15.5	3.8	13.6	2.05	-.43
9000.0	-7.0	-7.7	10.6	3.6	6.6	.42	.33
9500.0	-7.1	-8.5	9.8	3.5	4.8	.29	.78
10000.0	-4.4	-8.4	11.4	3.2	6.2	.41	.51
10500.0	3.7	-7.7	7.2	2.7	2.1	.14	1.72
11000.0	3.4	-6.9	5.4	3.6	2.1	.15	1.64
11500.0	-3.7	-7.1	6.4	4.3	3.5	.23	1.02
12000.0	-5.7	-9.0	8.6	3.6	3.2	.22	1.19

TASK? PARAM? LIST? 1,4

NEW MEAS? N

Z --MAGN AND ANGLES:

FREQ	11		21		12		22	
8000.0	20.235	84	21.733	5	2.537	-44	26.850	65
8500.0	38.569	88	24.781	0	2.974	-48	43.325	73
9000.0	55.666	87	30.406	-11	3.898	-57	67.889	73
9500.0	72.563	87	42.089	-22	5.709	-65	95.742	70
10000.0	121.004	90	106.901	-43	15.097	-85	177.991	56
10500.0	399.332	70	494.723	-132	71.600	-174	324.687	-18
11000.0	207.787	-63	148.444	43	21.488	4	99.941	-66
11500.0	74.309	-80	34.341	11	5.005	-25	52.857	-75
12000.0	38.029	-84	15.114	-2	2.301	-40	29.145	-70

TASK? PARAM? LIST?

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: B336b-45

V_D = 7.5 V, I_{DSSO} = 1100 mA, V_G = -2 V, f = 9.0 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	P_{out}-P_{in}(mW)	η_{PA}(%)
80	296.45	5.7	786		
160	508.20	5.0	803		
240	635.25	4.2	799		
320	738.10	3.6	773		
400	834.9	3.2	724	434.9	8.0

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: B336b-45

V_D = 7.5 V, I_{DSSO} = 1100 mA, V_G = -2 V, f = 9.5 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	P_{out}-P_{in}(mW)	η_{PA}(%)
76	222.25	4.7	760		
152	457.20	4.8	807		
228	622.30	4.4	805		
304	698.5	3.6	803		
380	793.75	3.2	777	413.75	7.1
456	882.65	2.9	735		

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: B336b-45

V_D = 7.5 V, I_{DSSO} = 1100 mA, V_G = -2 V, f = 10 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	P_{out}-P_{in}(mW)	η_{PA}(%)
76	226	4.7	762		
152	445.55	4.7	805		
228	585.20	4.1	800		
304	678.30	3.5	793		
380	784.70	3.1	774	404.7	6.97
456	871.15	2.8	730		

TASK? PARAM? LIST? 1,3

NEW MEAS? Y

CONN DEVICE B336B-45 V_{DS}, V_{GS}, I_{DS} 4,-5,5.480 5 CELLS 8/19/76 J.JN

S --MAGN AND ANGLES:

FREQ	11		21		12		22	
8000.0	.839	163	.516	-1	.070	-52	.629	137
8500.0	.872	158	.430	-8	.060	-58	.639	136
9000.0	.895	162	.372	-11	.055	-59	.614	142
9500.0	.882	166	.350	-10	.055	-56	.562	151
10000.0	.824	166	.383	-13	.061	-57	.517	152
10500.0	.727	163	.416	-20	.069	-63	.539	140
11000.0	.674	147	.421	-36	.071	-76	.576	123
11500.0	.782	135	.409	-48	.069	-89	.657	115
12000.0	.858	119	.331	-69	.058	-112	.694	102

TASK? PARAM? LIST? 2

NEW MEAS? N

FREQ	H21	S21	G1	G2	GMAX	U	K
8000.0	-1.7	-5.8	5.3	2.2	1.7	.11	1.96
8500.0	-3.4	-7.3	6.2	2.3	1.2	.10	2.20
9000.0	-4.0	-8.6	7.0	2.1	.5	.09	2.48
9500.0	-3.7	-9.1	6.5	1.7	-.9	.06	3.53
10000.0	-3.0	-8.3	4.9	1.4	-2.0	.04	4.63
10500.0	-2.9	-7.6	3.3	1.5	-2.9	.03	5.51
11000.0	-3.9	-7.5	2.6	1.7	-3.1	.03	5.77
11500.0	-5.3	-7.8	4.1	2.5	-1.2	.07	3.47
12000.0	-8.3	-9.6	5.8	2.9	-1.0	.08	3.17

TASK? PARAM? LIST? 1,4

NEW MEAS? N

Z --MAGN AND ANGLES:

FREQ	11		21		12		22	
8000.0	8.650	53	18.811	22	2.566	-29	22.920	52
8500.0	10.005	66	15.396	17	2.155	-31	22.763	54
9000.0	7.959	66	12.981	10	1.934	-37	20.659	48
9500.0	6.612	58	12.392	5	1.933	-39	18.963	36
10000.0	7.543	46	14.382	1	2.301	-42	20.227	31
10500.0	10.714	37	16.813	0	2.781	-43	23.382	42
11000.0	17.041	50	18.643	-4	3.138	-44	29.194	53
11500.0	20.802	69	17.509	-5	2.950	-45	32.144	63
12000.0	28.855	79	15.333	-11	2.666	-54	39.839	68

TASK? PARAM? LIST?

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: B336b-82

V_D = 7.5 V, I_{DSSO} = 900 mA, V_G = -2 V, f = 9.0 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	$P_{out}-P_{in}$(mW)	η_{PA}(%)
80	344.9	6.3	583		
160	653.4	6.1	620		
240	840.95	5.4	575		
320	980.1	4.9	530	660.1	16.6

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: B336b-82

V_D = 7.5 V, I_{DSSO} = 900 mA, V_G = -2 V, f = 9.5 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	P_{out}-P_{in}(mW)	η_{PA}(%)
76	342.9	6.5	586		
152	584.2	5.8	611		
228	736.6	5.1	581		
304	850.9	4.5	530	546.9	13.8

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: B336b-82

V_D = 7.5 V, I_{DSSO} = 900 mA, V_G = -2 V, f = 10 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	P_{out}-P_{in}(mW)	η_{PA}(%)
76	279.3	5.7	581		
152	545.3	5.5	623		
228	704.9	4.9	604		
304	837.9	4.4	553	533.9	12.9

1,1

NEW MEAS? Y

CONN DEVICE B336-8-92 V_{DS}, V_{GS}, I_{DS} 4 CELLS 8/29/77 JJN

S --MAGN AND ANGLES:

FREQ	11		21		12		22	
8000.0	.868	-173	.634	10	.075	-43	.630	135
8500.0	.854	-177	.528	2	.067	-45	.682	134
9000.0	.893	-176	.474	0	.062	-51	.718	139
9500.0	.905	-175	.457	-2	.060	-53	.709	145
10000.0	.853	-174	.442	-5	.063	-54	.688	148
10500.0	.823	-173	.473	-10	.069	-56	.652	140
11000.0	.783	178	.490	-22	.074	-66	.674	116
11500.0	.793	169	.473	-35	.071	-76	.731	97
12000.0	.857	158	.386	-49	.062	-89	.766	85

TASK? PARAM? LIST? 2

NEW MEAS? N

FREQ	H21	S21	G1	G2	GMAX	U	K
8000.0	-.4	-4.0	6.1	2.2	4.3	.17	1.05
8500.0	-1.9	-5.5	5.7	2.7	2.9	.14	1.49
9000.0	-2.2	-6.5	6.9	3.1	3.6	.19	1.07
9500.0	-1.9	-7.2	7.4	3.0	3.3	.19	1.17
10000.0	-1.1	-7.1	5.7	2.8	1.3	.11	2.10
10500.0	-1.9	-6.5	4.9	2.4	.8	.09	2.40
11000.0	-4.4	-6.2	4.1	2.6	.6	.09	2.44
11500.0	-6.7	-6.3	4.3	3.3	1.1	.12	1.95
12000.0	-9.7	-8.3	5.8	3.8	1.3	.14	1.71

TASK? PARAM? LIST? 1,4

NEW MEAS? N

Z --MAGN AND ANGLES:

FREQ	11		21		12		22	
8000.0	5.443	-36	22.763	24	2.684	-29	23.775	53
8500.0	4.682	-16	18.432	19	2.329	-33	22.970	59
9000.0	3.649	-27	15.623	14	2.047	-36	20.176	60
9500.0	3.498	-36	14.143	9	1.927	-41	17.590	56
10000.0	5.195	-34	14.734	4	2.101	-45	16.833	51
10500.0	6.109	-31	16.791	1	2.462	-44	20.788	53
11000.0	6.438	0	19.302	2	2.916	-41	32.019	63
11500.0	7.214	32	20.226	1	3.149	-39	43.737	70
12000.0	9.707	65	17.380	-1	2.794	-41	52.987	74

TASK? PARAM? LIST?

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: B336b-103

V_D = 7.5 V, I_{DSSO} = 750 mA, V_G = -2 V, f = 9.0 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	$P_{out}-P_{in}$(mW)	η_{PA}(%)
80	326.7	6.1	533		
160	605.0	5.8	521		
240	756.3	5.0	480		
320	840.95	4.2	464	520.95	14.97

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: B336b-103

V_D = 7.5 V, I_{DSSO} = 750 mA, V_G = -2 V, f = 9.5 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	P_{out}-P_{in}(mW)	η_{PA}(%)
76	304.8	6.0	527		
152	565.15	5.7	517		
228	730.25	5.1	475		
304	749.3	3.9	453		
380	787.4	3.2	444	407.4	12.2

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: B336b-103

V_D = 7.5 V, I_{DSSO} = 750 mA, V_G = -2 V, f = 10 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	P_{out}-P_{in}(mW)	η_{PA}(%)
76	260.7	5.4	515		
152	518.7	5.3	529		
228	658.4	4.6	498		
304	751.5	3.9	473		
380	811.3	3.3	456	431.3	12.6

NEW MEAS? Y

CONN DEVICE B336B-103 V_{DS}, V_{GS}, I_{DS} 5,-3,450 3 CELLS 8/23/76 JJN

S --MAGN AND ANGLES:

FREQ	11		21		12		22	
8000.0	.805	168	.654	-5	.077	-67	.712	152
8500.0	.851	165	.524	-14	.062	-74	.756	150
9000.0	.849	167	.426	-16	.054	-74	.751	152
9500.0	.869	171	.408	-18	.053	-73	.774	156
10000.0	.847	176	.419	-18	.055	-72	.739	159
10500.0	.786	177	.459	-20	.063	-73	.683	152
11000.0	.730	160	.548	-37	.076	-85	.760	130
11500.0	.781	137	.546	-62	.078	-111	.802	111
12000.0	.734	133	.245	-92	.033	-144	.773	97

TASK? PARAM? LIST? 2

NEW MEAS? N

FREQ	H21	S21	G1	G2	GMAX	U	K
8000.0	3.6	-3.7	4.5	3.1	3.9	.17	1.27
8500.0	1.2	-5.6	5.6	3.6	3.6	.17	1.39
9000.0	-.3	-7.4	5.5	3.6	1.7	.12	2.27
9500.0	.4	-7.8	6.1	4.0	2.3	.15	1.96
10000.0	1.2	-7.6	5.5	3.4	1.4	.11	2.55
10500.0	.3	-6.8	4.2	2.7	.1	.08	3.33
11000.0	-1.3	-5.2	3.3	3.7	1.8	.12	2.06
11500.0	-3.7	-5.3	4.1	4.5	3.3	.19	1.38
12000.0	-11.7	-12.2	3.4	4.0	-4.9	.03	11.50

TASK? PARAM? LIST? 1,4

NEW MEAS? N

Z --MAGN AND ANGLES:

FREQ	11		21		12		22	
8000.0	7.338	34	22.061	9	2.608	-51	14.584	48
8500.0	7.328	53	16.870	4	1.984	-55	14.629	57
9000.0	6.600	49	13.642	0	1.718	-57	14.054	56
9500.0	4.953	43	12.620	-4	1.639	-59	12.096	55
10000.0	4.439	17	13.267	-7	1.730	-62	11.586	46
10500.0	6.095	4	15.731	-8	2.140	-62	15.225	48
11000.0	10.886	42	20.050	-8	2.775	-57	23.311	68
11500.0	19.168	69	21.789	-14	3.109	-64	33.455	76
12000.0	22.509	66	11.391	-38	1.553	-89	43.828	75

TASK? PARAM? LIST?

APPENDIX B

DATA PACKAGE FOR 16-GATE FETs

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: 2973-24 (16 gate)

V_D = 7.0 V, I_{DSSO} = 420 mA, V_G = -2 V, f = 8.0 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	P_{out}-P_{in}(mW)	η_{PA}(%)
14.8	72.59	6.9	220		
29.6	133.28	6.5	214		
44.4	190.4	6.3	211		
59.2	235.6	6.0	210		
74	273.7	5.7	210	199.7	13.6

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: 2973-34 (16 gate)

V_D = 7 V, I_{DSSO} = 640 mA, V_G = -2 V, f = 8 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	P_{out}-P_{in}(mW)	η_{PA}(%)
37	170.17	6.6	443		
74	304.6	6.1	442		
111	404.6	5.6	443		
148	476	5.1	445		
185	511	4.4	443	326	10.5
222	535.5	3.8	441		

RCA MESFET P_{in}-P_{out} CHARACTERISTICS

DEVICE: 2975-75 (16 gate)

V_D = 8.0 V, I_{DSSO} = 560 mA, V_G = -2.0 V, f = 8.0 GHz

P_{in}(mW)	P_{out}(mW)	G(dB)	I_D(mA)	P_{out}-P_{in}(mW)	η_{PA}(%)
37	148.75	6.0	285		
74	297.5	6.0	291		
111	422.45	5.8	299		
148	523.6	176.12	304		
185	583.1	5.0	305	398.1	16.4
222	618.8	4.5	304	396.8	16.3